STORMWATER TREATMENT AREA NO. 3 & 4

PLAN FORMULATION DOCUMENT

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1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

The Everglades Forever Act (EFA), enacted by the Florida Legislature in April 1994, directed the South Florida Water Management District (District) to design and construct the Everglades Construction Project (ECP). Critical components of the ECP are the six large constructed wetlands referred to as Stormwater Treatment Areas (STAs). The STA construction effort involves converting in excess of 45,000 acres of land, generally located in agricultural areas, to wetland treatment areas intended to reduce the total phosphorus concentrations from the Everglades Agricultural Area (EAA) and other sources prior to discharging into the Water Conservation Areas (WCA), the Everglades Protection Area (EPA). Associated with STA-3/4 are canal improvements and other water control structures necessary to distribute discharges from STA-3/4 to downstream water bodies. These associated works are referred to as the East WCA-3A Hydropattern Restoration Works.

The required works of the overall project are described in the *Everglades Protection Project, Conceptual Design* dated February 15, 1994 by Burns & McDonnell, and as modified by the EFA. Burns & McDonnell subsequently completed the *General Design Memorandum, Stormwater Treatment Area Nos. 3 and 4 and East WCA–3A Hydropattern Restoration* in April 1996, and a comprehensive *Alternatives Analysis* for STA-3/4 and the East WCA-3A Hydropattern Restoration in September 1999.

This document serves as the Plan Formulation for the basic design of STA-3/4, and builds on the results of those earlier efforts. This *Plan Formulation* document and companion documents (further described below) are intended to develop the basic design of STA-3/4 to the extent necessary to define and evaluate all factors controlling the basic layout of the treatment area and related works. Conclusions and recommendations

reached herein establish basic criteria for the overall layout and hydraulic and nutrient removal performance of STA-3/4.

1.1.1 General Content of this Document

This *Plan Formulation* document:

- Defines the basic configuration for the treatment area interior, including definition of the spatial arrangement and extent of all primary features of the treatment area.
- Provides documentation of physical investigations and subsequent analyses intended to develop estimates of seepage losses from the treatment area and related works.
- Defines and summarizes hydrologic data employed in long-term simulations of the treatment area operation.
- Presents the results of two-dimensional hydrodynamic modeling conducted to verify an appropriate and sufficiently uniform distribution of flow in the treatment area interior.
- Presents the results of a long-term simulation of the operational performance of STA-3/4.
- Defines basic conveyance requirements for all primary canals in the project.
- Defines controlling discharge capacities and design headwater and tailwater elevations for all hydraulic control structures.
- Updates estimates of the projected treatment performance in STA-3/4, reflecting the results of the long-term simulation and updated estimates of treatment system parameters.
- Assesses the potential impact of the project on the hydrology and operation of the Holey Land Wildlife Management Area, and provides recommendations for mitigating adverse impacts.
- Presents a summary of existing vegetative communities on the project site, and provides an estimate of the impacts of the project on jurisdictional wetlands.

- Updates evaluation of the project for flexibility to accommodate advanced technologies as may be necessary for eventual conformance to the Phase 2 discharge standards, once established.
- Identifies all significant changes from the original February 1994 *Conceptual Design* reflected in the current preliminary design.
- Provides additional recommendations for further refinements to the design to be considered during the detailed design phase.

The preliminary design recommended herein is indicated graphically on a series of plates included in this document immediately following the end of this Executive Summary.

1.1.2 Companion Documents

Companion documents to this Plan Formulation, all prepared by the Burns & McDonnell team and completed following District review at or near the end of June 2000, include:

- A *Plan Implementation* document. That document includes:
  - Definition of the current status in acquisition of necessary lands.
  - Delineation of the number and established content of all construction and equipment procurement contracts necessary for completion of the project.
  - Discussion of drainage and site dewatering during construction.
  - A preliminary opinion of the construction cost of the project.
  - A detailed schedule for the final design, construction and startup of the project.
- A *Final Design Criteria* document for the primary pumping stations. That document includes:
  - Determination of the number and capacity of pumping units at each pumping station.
  - Definition of design criteria and parameters for ancillary mechanical equipment.
  - Design criteria for pumping station communications and control systems.
  - Electrical, structural, architectural and sitework systems and design criteria.

- Final hydraulic design criteria for the pumping stations, together with definition of controlling layouts and dimensions for the pumping stations.

- A *Final Design Criteria* document for other STA works. That document includes detailed design criteria for:
  - Levee embankment designs.
  - Levee profile grades.
  - Civil, structural, and mechanical basic design for control structures, including layouts and structure configurations.
  - Access for construction and operation.
  - Electrical and communications and controls basic design for the project other than pumping stations.
  - Civil, structural and geotechnical design criteria for roadway bridges, including new bridges on U.S. Highway 27 and on North Levee L-5.

1.2 BASIC REQUIREMENTS

Stormwater Treatment Area 3 & 4 (STA-3/4) is intended to improve the quality of waters discharged to the Everglades Protection Area from the S-7/S-2 and S-8/S-3 basins. Nominally, those discharges include all those flows which would, in the absence of STA-3/4, be discharged to WCA-2A via the North New River Canal at existing Pumping Station S-7, and to WCA-3A via existing Pumping Station S-8.

The design of STA-3/4 as discussed herein is further intended to achieve, at a minimum, the interim goal established in the Everglades Forever Act for total phosphorus in those discharges (e.g., a long-term, flow-weighted mean TP concentration of 50 ppb). It is the District's intent to maximize the performance of STA-3/4 in reducing total phosphorus concentrations, within schedule constraints imposed by the Everglades Forever Act (completion of STA-3/4 is required no later than October 1, 2003) and in recognition of funding constraints.

The Everglades Forever Act also establishes mechanisms and time lines for establishment of long-term numeric standards for total phosphorus concentrations in discharges to the EPA, which will supercede the above interim goal of 50 ppb. That final standard (or standards) is not presently known, but can be expected to be substantively below 50 ppb; in the event the statutory time line for establishing that standard is not met, the EFA imposes a long-term standard of 10 ppb.

The basic footprint of STA-3/4 and definition of basic requirements for controlling inflow and outflow works was established in the September 20, 1999 *Alternatives Analysis* prepared for the District by Burns & McDonnell. That *Alternatives Analysis* was prepared in support of the District's federal permitting requirements. It includes a reexamination of the design parameters used, including among other factors:

- Inflow volumes and phosphorus loads
- STA footprint
- Distribution of outflows
- Nutrient removal performance
- Canal conveyance
- Flexibility for incorporation of Advanced Technology under Phase 2 of the overall program mandated by the Everglades Forever Act.

The Plan Formulation developed in this document is consistent with the recommendations included in that *Alternatives Analysis,* unless otherwise expressly noted herein.

STA-3/4 is required to accommodate without bypass all discharges from the S-8/S-3 and S-7/S-2 basins given a repetition of the hydrologic conditions experienced during the period of water years 1979-1988. Bypass can be considered during more extreme hydrologic conditions than were experienced over that period, but should be minimized or prevented if practicable in order to maximize the overall treatment performance of the system. The preliminary design presented herein would require no

bypass given a repetition of the hydrologic conditions experienced during the period of calendar years 1965-1995, modified as necessary to reflect changes in regional hydrography and water management presently expected to prevail upon completion of the treatment area in 2003.

Target hydropatterns in the interior of the treatment area are based on criteria presented in the February 15, 1994 *Conceptual Design* prepared for SFWMD by Burns & McDonnell.

1.3 PRELIMINARY TREATMENT AREA CONFIGURATIONS

Section 3 develops and presents two alternative internal configurations (#1 - cells in parallel and #2 - cells in parallel & series) of STA-3/4 for subsequent evaluation. Topographic surveys were conducted to determine the right-of-way and to develop proposed configurations with due consideration of:

- surface topography
- soil characteristics
- treatment area shape
- hydraulic and total phosphorus (TP) loading
- maximization of available treatment area and flexibility for advanced treatment

For either of the two alternative configurations of STA-3/4, it is anticipated that the maximum amount of effective treatment area that can be developed on the lands available to the District for that purpose is approximately 16,394 acres. That total is roughly 98.4% of the target minimum area of 16,660 acres recommended in the *Alternatives Analysis*, and 99.5% of the minimum area recommended in the *General Design Memorandum* (16,480 acres).

On the basis of the preliminary analyses presented in Section 3 and further evaluation in subsequent sections of this Plan Formulation, it is recommended that the alternative treatment area configuration, in which cells in series are included to the maximum extent reasonably attainable, be carried forward in the detailed design.

1.3.1 Treatment Area Configuration, Base Design

The base design configuration incorporates three cells in parallel. Cell 1, approximately 39% of STA-3/4 area, is the most easterly of the three cells, and would be generally dedicated to the treatment of inflows from the North New River Canal. Cells 2 and 3, approximately 33% and 28% of STA-3/4 area, would be generally dedicated to the treatment of inflows from the Miami Canal. Cell 1

Advantages of the base design (as compared to the alternative design discussed in the following section) include its design simplicity, minimal hydraulic losses (resulting in lowered hydropattern), and lower construction cost. Disadvantages of this design include little or no flexibility in the treatment process and no provisions for alternative vegetative communities.

1.3.2 Treatment Area Configuration, Alternative Design

The alternative design includes both cells in series as well as in parallel. This design is identical to the base design except that both cells 1 and 2 would be split into two nearly identically-sized cells, 1a & 1b, and 2a & 2b, respectively. Advantages of the alternative design (as compared to the base design) include increased treatment efficiency, provision for different vegetative communities, increased control of depths and hydropattern, and increased operational flexibility / incorporation of advanced treatment technologies. The only factors potentially limiting the capacity to develop cells in series are budgetary limitations.

1.4 SEEPAGE INVESTIGATIONS AND ANALYSIS

Section 4 includes the results of a hydrogeologic and geotechnical investigation of site specific data for use in seepage and groundwater modeling evaluations. The preliminary subsurface investigation conducted for the project is documented in the October 1999

Report of Preliminary Subsurface Investigation and Geotechnical Engineering Evaluation, Nodarse & Associates.

The hydrogeologic field investigation included

- Five 4" dia. test wells, one selected for subsequent APT
- Six 2" dia. monitor wells
- 96-hour aquifer performance test (APT)

All cross sections were modeled as multi-layered subsurface extending to 100 ft. below ground surface (BGS). Horizontal conductivities were estimated for two cases:

- values obtained from geotechnical investigations in the upper 25 ft. (generally peat overlying limestone caprock overlying silty sands):
  - Lab falling head permeability tests on peat
  - Field constant head permeability tests on limestone cap rock
  - Combination of field constant head permeability tests on upper 25 ft. and an effective hydraulic conductivity formula combining the results of all three test methods
- Conductivity of the lower 85 ft. determined from APT results and an effective hydraulic conductivity formula

Vertical conductivities were estimated in two ways:

- Published ratios of vertical to horizontal conductivities used in previous STA designs
  - Vary from 20% to 50% of horizontal conductivity
- Calibration of APT test data
  - Results in ratios of vertical to horizontal conductivities at the lower end of the range of published values; 0.5% to 5% of horizontal conductivity

The seepage analysis analyzed perimeter conditions through us of two-dimensional modeling technique (SEEP2D), global conditions through used of three-dimensional modeling technique (MODFLOW). Three sets of estimated seepage transfer rates were developed:

- Scenario 1: MODFLOW analysis calibrated to the results of the field APT

- Scenario 2: SEEP2D results with previously published values of vertical-horizontal conductivity ratios
- Scenario 3: SEEP2D results with vertical conductivity based on results of MODFLOW analysis

The general observations for each of these scenarios is the following:

- Scenario 1 (MODFLOW calibrated to APT) results in lowest rates
- Scenario 2 (SEEP2D with published values of conductivity ratio) results in highest rates (factor of 8-10 times Scenario 1) and is considered conservative
- Scenario 3 (SEEP2D with vertical conductivity from APT) results in intermediate rates (factor of 2-8 times Scenario 1); generally considered best estimate, but may understate influence of regional hydrogeology

The rates used in the design vary by application to assure adequate conservatism in design and decision-making process, given inherent uncertainties in the analyses. Scenario 2 is used for design of seepage collection canal and seepage return pumps; pumping capacity is further increased by 50% for additional factor of safety and installed standby. Scenario 3 is used for operational simulation; it should somewhat overstate actual seepage to assure a robust basis for estimating the potential need for supplemental water and design decisions driven by seepage management strategies.

1.5 HYDROLOGIC DATA

Section 5 summarizes the hydrologic data employed in long-term simulations of the hydrologic performance of STA-3/4, determines whether or not the hydrologic annual inflow data differs significantly from the data in *Conceptual Design* (CD) or *Alternatives Analysis* (AA), and determines whether or not the 1979-88 period was drier than normal (i.e. 1965-95) and compares inflow volumes during peak events. The hydrologic data (i.e. precipitation, evapotranspiration, and inflow) are taken from a South Florida Water Management Model (SFWMM) simulation. The simulation is intended to represent

overall regional conditions which will exist upon completion of STA-3/4 construction (2003) as recommended in the AA.

The assumptions for the inflow simulations are the following:

- Current (1995) water supply demands on the regional system
- All components of the Everglades Construction Project in place
- EAA runoff reduction due to BMPs not greater than 20% per 40-E63 FAC
- Lake Okeechobee stages regulated under the WSE schedule
- Discharges to the EAA limited by existing conveyance capacity
- Lake regulatory releases directed to STA-3/4
- Improved performance in operation of the C&SF Project under the Interim Action Plan
- Increased percentage of EAA runoff directed south as compared to historic
- BMP makeup water for the S-7 and S-8 basins directed to STA-3/4, computed as required under 40-E63 FAC

Compared to the *Conceptual Design* and *Alternatives Analysis,* the PFD inflows are comparable. The percentage dedicated to North New River and Miami canals are different due to redirection of BMP make-up waters to Miami Canal. Between the different periods of records, total inflow is similar due to management strategies which increased water flow during low runoff years.

The analysis shows that the 1979-88 period is dryer than the 1965-95 period. Yet, the annual average rainfall rate is comparable to the rate used in *Conceptual Design*. The evapotranspiration rates which are based on the modified Penman-Monteith equation and are a function of the water depth and vegetation coefficient of each of the model grids, are higher than values from the *Conceptual Design*.

1.6 TWO-DIMENSIONAL HYDRAULIC ANALYSES

Section 6 presents the results of detailed hydraulic analyses of both the Base design configuration and the alternative design configurations which were evaluated using Two-Dimensional (2-D) hydrodynamic models. Based on these evaluations, several design modifications were identified, additional models were developed, and recommendations for the STA's final design configuration were identified. Section 6 presents a detailed analysis and evaluation of the base and alternative design configurations taken from Section 3, and recommends the final internal configuration of the STA.

Section 6 developed detailed information to:

- Evaluate the number, location, performance, and design criteria to be used for inflow and outflow control structures
- Identify each design configuration's 2-D hydraulic performance characteristics and evaluate the need to construct interior berms or filling canals to improve the overall hydropattern, minimize short-circuiting, and/or prevent re-suspension of particulate matter
- Generate data that will be used to establish stage/storage relationship for each treatment cell, for use in levee design and long-term simulations of the STA's performance

A depth-varying Manning's "n" is used in the analysis which is consistent with previous estimates and other STA studies.

Results show that with modified outflow configurations, the flow through the STA cells generally show good to excellent distribution. Other key refinements identified during the model process include:

- Relocation or addition of flow control structures
- Filling or plugging existing transverse ditches within the treatment cells
- Enlargement or other increases in the conveyance capacities of the collections canals

- Adding canals or interior berms

1.7 OPERATIONAL SIMULATIONS

Section 7 presents an assessment of the degree to which anticipated stage-durations and minimum and maximum depths in the interior of the treatment can be expected to conform to the current basis for design. It also evaluates the impact of alternative seepage management schemes, develops a complete water balance for alternative seepage management strategies, and identifies the degree to which the presence and operation of STA-3/4 may result in additional inflows (primarily due to induced seepage) to the Holey Land Wildlife Management Area.

Section 7 presents estimated seepage losses and recoveries, supplemental inflows necessary to prevent dryout of the treatment area, and computes a full suite of projected treatment area outflows and stages. Three seepage management operational scenarios were considered in detail:

- Scenario 1 - All recoverable seepage directly discharged
- Scenario 2 - All recoverable seepage returned to the treatment area
- Scenario 3 - Recoverable seepage returned only when cell(s) drop below Static Water Surface Elevation, and directly discharged at other times (e.g., when positive flow conditions exist in the STA)

The results show that the supplemental water requirements under Scenarios 2 and 3 are small as compared to Scenario 1, and that depth-durations in the treatment area conform well to target depth-durations for each of the three scenarios considered. The results also demonstrate that there is no significant difference between scenarios with respect to the total volume of water discharged to the Everglades Protection Area.

1.8 CANAL AND STRUCTURE HYDRAULICS

Section 8 presents the hydraulic design criteria for G-371, G-373, supply canal, inflow canal and inflow control structures; and discharge canal, L-5 Canal and outflow control structures. Section 8 also establishes design headwater and tailwater elevations for all structures and models the proposed distribution of STA outflows. These modeling efforts were conducted in parallel with the 2-D modeling efforts of Section 6.

Structures G-371 and G-373 are diversion and bypass control structures in the primary canals. Normally closed, they are operated (gates opened) only to bypass:

- Lower East Coast water supply deliveries around STA-3/4
- When necessary due to operational upset or extreme hydrologic event

The treatment area canals were analyzed using one-dimensional HEC-RAS models to:

- Evaluate the facilities' capability to convey water at rates and with profiles consistent with the effective use of the proposed pump station and canal capacity
- Balance the required canal conveyance capacities with the need to minimize excavation requirements
- Model the proposed distribution of the STA outflows through the discharge canal and to the L-5 Borrow Canal and downstream works, consistent with recommendations in *Alternatives Analysis*

1.9 TREATMENT PERFORMANCE PROJECTIONS

Section 9 presents estimates of the maximum, minimum and expected performance of STA-3/4 in reducing the concentration of total phosphorus in discharges to the Everglades Agricultural Area. Section 9 also presents a comparison of performance between the three operational scenarios and the influence of different levels of BMP's.

The total phosphorus inputs are taken from *Baseline Data for the Basin-Specific Feasibility Studies to Achieve the Long-Term Water Quality Goals for the Everglades,* South Florida Water Management District, 2000:

- Lake Okeechobee Releases – 1990-99 flow-weighted mean applied 66.6 ppb to Miami Canal flows and 72.2 ppb to North New River flows
- 298 & S-236 Basin – from 1994 Conceptual Design – 100 ppb applied to Ch. 298 District runoff and 136 ppb applied to S-236 Basin runoff
- Basin runoff are based on daily regression of historic phosphorus concentrations applied to the S-7 and S-8 basins, and corresponds to 50% BMP performance
- Basin runoff loads are increased by 150% for 25% BMP performance
- G-136 values are also daily regression values applied to G-136 inflows

The phosphorus input applied to rainfall (30 ppb) was taken from Central and Southern Florida Project, Comprehensive Review Study, Integrated Feasibility Report and Programmatic Environmental Impact Statement, Jacksonville District U.S. Army Corps of Engineers, 1999. The total phosphorus concentration of 25 ppb applied to recovered seepage and infiltration (groundwater upwelling in treatment area) were taken from reported concentrations in seepage waters recovered in the Everglades Nutrient Removal Project.

The projected treatment performance model was taken from Section 3 of the 1999 Alternatives Analysis. Three estimates of the treatment parameters, apparent TP settling rate and C*(minimum concentration attainable), were used in the analysis:

- Worst - values originally employed in the 1994 *Conceptual Design*, which were based on analysis of data from impacted zones in WCA-2A
- Best - values resulting from analysis of data taken from the Everglades Nutrient Removal Project, from 1999 *Alternatives Analysis*
- Expected - current estimates considered most representative (ATTI estimates)

The treatment performance results were compared to permit compliance tests established for previously constructed STAs of the Everglades Construction Project:

- Flow-weighted discharge conc. not exceeding 76 ppb in any given year
- Flow-weighted discharge conc. not exceeding 50 ppb in 2 of any 3 years

The results showed that

- The maximum annual flow-weighted concentration computed under any analysis is 62 ppb
- Only under highly conservative estimates does the annual flow-weighted concentration exceed 50 ppb for 2 years in any 3
- There is a high degree of confidence that the completed treatment area will meet and exceed the interim goals established by the Legislature in the Everglades Forever Act.
- Very little difference exists between the projected performance of the three operational scenarios considered in detail.

1.10 HOLEY LAND IMPACTS

Section 10 presents an evaluation of the potential seepage, discharge, phosphorus loads and recreational access impact of STA-3/4 on the Holey Land Wildlife Management Area, and presents recommendations for mitigation.

The potential impacts of STA-3/4 are the following:

- Recreational Access - no impact due to STA-3/4 construction and operation
- Additional seepage inflows induced by the project aggregated to
  - an additional 14,654 acre-feet (Scenario 1) to 19,624 acre-feet (Scenario 2) per year is projected along with North & East Boundary
  - an additional 39,128 acre-feet maximum annual inflow

The net addition to Holey Land average annual water balance is roughly 56,000 acre-feet due to these future changes:

- net average annual inflow due to seepage (under Scenario 2) is 19,624 acre-feet per year
- Given elevated stages along northern & eastern boundaries, the historic average annual net seepage loss is eliminated (36,000 acre-feet per year)

In addition, the TP load is reduced by 1.1 tonnes due to the corresponding water balance changes:

- 19,624 acre-feet of seepage (at 25 ppb) introduces 0.6 tonnes
- inflow at G-200A will conservatively expected to be reduced from 75 to 50 ppb reducing TP load by 1.7 tonnes

Under the maximum annual water balance over the 31 years considered, 75,000 acre-feet is likely to be introduced yet the TP load would be essentially unchanged.

The following recommendations for mitigating those impacts are proposed, and are considered adequate to fully mitigate for any potential increased inflows to the Holey Land:

- Operation of inflow pumping station G-200A should be limited to the minimum necessary to address other water management needs in the S-8/S-3 basin, and not be initiated solely for the purpose of increasing Holey Land stages
- Seepage return pumping station G-201 may be taken out of service, but should be left in place for future operational flexibility
- Structures G-204, G-205 and G-206 should be used to effect necessary discharges from the Holey Land
- Seepage return pumping station G-200B may be taken out of service and should be physically removed.

1.11 VEGETATION SURVEY AND IMPACTS TO WETLANDS

Section 11 defines the nature of vegetation and assesses probable impacts to WCA-3A, L-5 Borrow Canal, Supply Canal, Disjunct Areas (i.e. jurisdictional wetlands in the immediate vicinity of existing pump stations) and STA-3/4. The survey was performed by Environmental Permitting & Design (EPD) in 1999. The general method employed used tenth or quarter-mile transects to map & group similar vegetational dominant communities together to form community types.

The following are some of the general types of vegetation found in these areas:

- WCA-3A - mostly Sawgrass with some Willow/Cattail
- L-5 Borrow canal – Brazilian Pepper, Wetland Herbaceous, Sawgrass, Ragweed and Baccharis
- Supply Canal – Brazilian Pepper, Baccharis, Wetland Herbaceous, Brake Fern and Ragweed
- Disjunct Areas – Brazilian Pepper, Water Lettuce and other grasses/vegetation
- STA-3/4 – Brazilian Pepper, Willow, Cattail and Ludwigia

The general impact in the WCA-3A/L-5 area is limited to the filling of approximately 90 acres in the L-5 right-of-way along the south face of South Levee L-5, and to less than 2 acres in the disjunct areas.

This limited impact on existing jurisdictional wetlands, coupled with the significant decision to avoid substantial impacts in WCA-3A by modifying the project design to eliminate direct discharges with relatively high TP concentrations, demonstrates that the design of the project has been developed to minimize wetland impacts in accordance with the requirements of the Everglades Forever Act.

1.12 FLEXIBILITY FOR PHASE 2

Section 12 documents the progress regarding advanced treatment technologies (ATT) needed to comply with the state's probable future standard of 10 ppb as defined in the Everglades Forever Act (EFA). This research is required as macrophyte-based STAs cannot be reasonably projected to achieve TP levels that low. The EFA set December 31, 2001 for completion of research, 2003 for development of appropriate strategy for meeting compliance, and 2006 for meeting compliance with the final phosphorus criterion.

To achieve this, research is continuing on these five potential technologies:

- Chemical Treatment/Solids Separation (CTSS)
- Low-Intensity Chemical Dosing in Wetlands (LICD)
- Managed Wetland Treatment Systems (MWTS)
- Submerged Aquatic Vegetation/Limerock (SAV)
- Periphyton-Based Stormwater Treatment Areas (PSTA)

The present ATT status is that research and evaluation of alternative technologies has not progressed to a point which would permit identification of the most appropriate technology or the optimal combination of technologies. Hence, an adaptive management approach should be undertaken to learn during the process of system design, construction and operation rather than wait for when all research information is finally assembled. In light of the legislatively mandated completion schedule for STA-3/4, maximum flexibility must exist in all design and operation aspects of STA-3/4 to facilitate subsequent addition of ATT under Phase 2 of the Everglades Construction Project.

Thus, flexibility for Phase 2 incorporated in the design includes, but is not limited to, the following:

- Use of multiple cells and cells in series wherever economically practical
- Automated control structures - independent inlet and outlet water control
- Control structure design permits variation in controlled headwater elevation down to ground surface
- Structures included to permit (rate limited) transfer of flows between parallel cells
- Space reserved in the vicinity of rock pits for potential Post-STA treatment
- All discharges hydraulically connected to permit maximum delivery to Post-STA treatment and distribution of discharges
- Excess excavated materials strategically placed in convenient location for subsequent addition of levees to further subdivide Cells 1B and 2B

Determinations to include the above features were driven primarily by the desire to maximize performance of the STA as originally constructed.

1.13 SUMMARY OF CHANGES TO 1994 *CONCEPTUAL DESIGN*

The preliminary design of STA-3/4 and the East WCA-3A Hydropattern Restoration presented in this *Plan Formulation* document varies in certain respects from the initial design presented in the February 1994 *Everglades Protection Project, Conceptual Design*. The following paragraphs summarize those changes, and define the basis upon which the changes were made.

1.13.1 Changes to Basic Treatment Area Footprint

The basic "footprint" of STA-3/4 presented in this Plan Formulation is fully consistent with that developed and recommended in the September 1999 *Alternatives Analysis* for STA-3/4 and the East WCA-3A Hydropattern Restoration. The development of a combined treatment area serving the S-7/S-2 and S-8/S-3 basins in the manner and general location contemplated in the Conceptual Design was validated and confirmed in connection with the development of that *Alternatives Analysis*. Significant changes to the footprint were established consistent with the intent of the Florida Legislature as

expressly stated in paragraph (4).(c) of the Everglades Forever Act (Section 373.4592 of the Florida Statutes), and include:

- Removal of the easternmost tract of the Holey Land Wildlife Management Area, known as the "Toe of the Boot", from the STA-3/4 treatment area.
- The inclusion of alternative lands to replace those originally represented by the Toe of the Boot. In the Everglades Forever Act, the Legislature authorized the acquisition of such alternative lands by eminent domain only if such lands were located within one mile of the northerly line of STA-3/4 as shown in the *Conceptual Design*. The preliminary design presented herein includes alternative lands extending to a line 5/6 mile north of the original north line. The northerly extent of the alternative lands was limited by the terms of the Talisman Land Exchange, under which much of the land necessary for construction of STA-3/4 was obtained.

The *Conceptual Design* had contemplated the development of 16,660 acres of effective treatment area in STA-3/4. Deletion of the Toe of the Boot from the treatment area, coupled with the removal of additional agricultural lands (the alternative lands referenced above) from production, was estimated in the April 1996 *General Design Memorandum* to result in a reduction of the required effective treatment area to 16,480 acres, given no other changes to the design basis. The preliminary design presented herein affords a total treatment area of 16,394 acres, measured to the centerline of perimeter levees. The extent of effective treatment area was limited primarily by the terms of the Talisman Land Exchange, but is also influenced to a lesser extent by the specific nature of physical works presented herein.

1.13.2 Estimated Inflow Volumes and Loads

The *Conceptual Design* was developed for an estimated average annual inflow volume to STA-3/4 of 604,753 acre-feet at a flow-weighted mean inflow TP concentration of 120 ppb. Those inflows included an average of 252,331 acre feet of Lake Okeechobee regulatory releases at a flow-weighted mean TP concentration of approximately 70 ppb.

The basis of design presented in the Conceptual Design excluded consideration of any additional Lake Okeechobee releases for BMP makeup water. Those inflow volumes and loads were developed from analysis of historic data for a 10-year base period encompassing water years 1979-1988, adjusted by approximate means to reflect the presence of the Everglades Construction Project facilities.

In this analysis, average annual inflows to STA-3/4 from the North New River and Miami Canal at pumping stations G-370 and G-372, respectively, are estimated to total 645,222 acre-feet at a flow-weighted mean TP concentration of 114 ppb. Those inflows include an average annual Lake Okeechobee regulatory release of 106,440 acre-feet at a flow-weighted mean TP concentration of 69 ppb, and average annual BMP makeup water releases of 115,133 acre-feet at a flow-weighted mean TP concentration of 67 ppb. Those inflow volumes and loads were developed from analysis of simulated data for a 31-year period encompassing calendar years 1965-1995, developed to reflect the presence of the Everglades Construction Project facilities and other changes to the regional hydrography and operation anticipated to exist upon completion of STA-3/4. Those inflow volumes and loads are based on strict compliance of BMP efforts in the EAA to the requirements of Chapter 40E-63 FAC (e.g., 25% reduction in TP loads discharged from the EAA). The reported performance of the BMP program to date (approximately a 50% reduction) would, if continued in the future, act to reduce the flow-weighted mean TP concentration in STA-3/4 inflows from 114 ppb to 86 ppb.

1.13.3 Inflow Pumping Capacity

In the *Conceptual Design*, the nominal capacity of new Pumping Station G-370 on the North New River Canal was estimated at 2,490 cfs, equal to the nominal capacity of existing Pumping Station S-7. The nominal capacity of new Pumping Station G-372 on the Miami Canal was estimated at 4,170 cfs, equal to the nominal capacity of existing Pumping Station S-8.

In this preliminary design, the nominal capacities of those inflow pumping stations have been reduced from 2,490 cfs to 2,170 cfs at G-370, and from 4,170 cfs to 3,670 cfs at G-372. The revised capacities were developed to maintain the current level of flood protection and drainage service afforded the tributary areas, and were developed and documented in detail in the September 1999 *Alternatives Analysis*.

Similar modifications were made to the nominal capacities of proposed structures G-371 and G-373 (diversion structures in the North New River and Miami Canal, respectively).

1.13.4 Outflow Distribution and Control

In the 1994 *Conceptual Design*, discharges from STA-3/4 were to be directed to the maximum practicable extent directly to WCA-3A via a sheet-flow approximation. That sheet-flow approximation was to be developed through complete degradation of the existing North and South Levee L-5, with STA outflows proceeding directly south by gravity flow whenever practicable. To the extent that gravity flow might not be supported under higher rates of discharge without exceeding desirable depths in the STA, existing pumping stations S-7 and S-8 were to remain in service and be available for use as outflow pumping stations to supplement gravity (sheet-flow) discharge capacities. STA outflows were to be gathered in a new collection canal and perimeter levee system along and immediately north of the FPL power transmission lines paralleling L-5. Those discharges were to be delivered to the L-5 Borrow Canal through a series of outflow control structures and outlet canals crossing the FPL right-of-way and leading to the L-5 Borrow Canal.

Subsequent to completion of the *Conceptual Design*, additional information developed throughout the general and preliminary design process has led to substantial modification of the nature of the STA-3/4 outflow distribution and control (East WCA-3A Hydropattern Restoration). Primary shortcomings of the original design concept included:

- An extremely limited ability to effect gravity discharge by sheet-flow to WCA-3A without undesirable stage increased in the STA. This limitation was made apparent upon the acquisition of current topographic data not available during preparation of the *Conceptual Design*.
- Undesirably high discharge volumes to East WCA-3A, coupled with an inappropriate timing of those discharges relative to restoration objectives.
- The discharge of water to the Everglades Protection Area at TP concentrations sufficient to potentially result in the displacement of desirable native species.

Additional regional analyses conducted in connection with the federal *Comprehensive Everglades Restoration Plan*, or CERP (formerly known as the *Restudy*) suggested the desirability of a substantial redirection of STA-3/4 discharges as compared to the original intent of the *Conceptual Design*.

A comprehensive analysis of outflow distribution and control alternatives was developed and evaluated in the September 1999 *Alternatives Analysis*. It was concluded and recommended in that *Alternatives Analysis* that the design of the STA-3/4 outflow distribution and control be substantively modified from that contemplated in either the *Conceptual Design* or the April 1996 *General Design Memorandum*. The preliminary design presented herein is, with one exception, fully consistent with the recommendations presented in the *Alternatives Analysis*. That exception consists of replacement of the Central L-5 Borrow Canal Enlargement with a new Discharge Canal along the south lines of Cells 1B and 2B. That modification is made to:

- Facilitate future modification of the overall design as may be necessary to support controlled sheet-flow discharges to WCA-3A once the performance of STA-3/4 has been improved, either through addition of Advanced Treatment Technologies or other means, to a degree sufficient to comply with final phosphorus criterion (once adopted) for discharges to the Everglades Protection Area.
- Minimize adverse impacts to existing FPL power transmission facilities and public access along North Levee L-5.

- Facilitate the incorporation of any post-STA Advanced Treatment Technologies into the overall design of STA-3/4.

This modification is estimated to result in little or no change to the overall construction cost of STA-3/4.

1.13.5 Internal Cell Configurations

The preliminary design presented herein includes the development of three parallel flow paths, consistent with the general arrangement of STA-3/4 presented in the *Conceptual Design*. The distribution of the overall area into those three paths varies in detail from the distribution of the *Conceptual Design*, and has been adjusted to permit separation of treatment area dedicated to inflows from the North New River from treatment area dedicated to inflows from the Miami Canal. That separation is considered desirable and necessary due to the anticipated variation in inflow water quality from those two primary sources, and to afford additional operational flexibility in maximizing the treatment performance of the STA.

Unlike the configuration of the Conceptual Design, the two easterly flow paths have each been further subdivided into two cells in series. That additional subdivision has been implemented in the design to improve overall treatment performance, and to further increase and enhance operational flexibility.

Structures G-382A, G-382B and G-383 have been added to the design to permit inter-cell transfers between parallel flow paths to further improve operational flexibility.

1.13.6 Control Structures

As presented in the *Conceptual Design*, the STA-3/4 inflow control structures were to consist of a series of 58 structures, each consisting of an 84-inch diameter CMP fitted with a manually operated sluice gate housed in a reinforced concrete gatewell. Those

sluice gates were included to permit both partial closure (throttling to facilitate an even distribution of flow) and full closure in the event it would be desired to remove one or more cells of STA-3/4 from service. Gates were to be manually operated; no provision for electric actuators or telemetric monitoring or control was included in the *Conceptual Design*.

The STA-3/4 outflow control structures were to consist of a series of 9 normally open structures (3 per parallel flow path). Each structure was to consist of a reinforced concrete spillway fitted with a single vertical lift roller gate. The structures were to be closed only when necessary to permit the cell they controlled to be removed from service. Gates were to be manually operated; no provision for electric actuators or telemetric monitoring or control was included in the *Conceptual Design*. The apparent design intent was to permit stages in the STA to vary in direct response to stages in the downstream WCA-3A, regulated to a minor degree by operation of pumping stations S-7 and S-8.

The preliminary design presented herein includes a total of 17 inflow control structures, 17 outflow control structures, and 11 intermediate control structures in the east-west levees dividing Cells 1 and 2 into cells in series. Each structure will consist of a reinforced concrete box culvert fitted with an operable gate capable of controlling headwater elevations in a full range from the ground surface to depths of four feet and greater. Each gate will be equipped with electric motor driven actuators, and capable of full remote monitoring and control via the District's telemetry system. The use of electrically operated and telemetrically controlled gates is included in the design primarily to reduce ongoing operation and maintenance costs, but will also permit rapid response to changing hydrologic conditions and improved operational flexibility.

1.13.7 Levee and Canal Geometrics

The preliminary design presented herein represents in most instances an improved definition of specific requirements for the various project levees and canals as would be expected for continued acquisition of specific topographic data and subsurface

information, and continued development of the detailed hydraulic performance requirements for the canals. However, there do exist two developments in this preliminary design that represent a basic enhancement in the intent of the *Conceptual Design*.

- Maintenance berms have been added along primary project canals to facilitate maintenance, and in some instances to limit the potential for seepage exiting at or near the toe of project levees. These berms are generally constructed of materials that would have needed to be excavated in any event to achieve the hydraulic performance requirements of the project, and do not represent an incremental cost.
- In the *Conceptual Design*, interior levees separating the various flow paths were to be constructed from immediately adjacent borrow canals. Those borrow canals, which would generally follow the intended flow path in the treatment area, would represent an increased probability of flow short-circuiting and reduced treatment performance. As presented herein, those levees will be constructed of material hauled from other excavations on the project, and the adjacent borrow canals are eliminated.

1.13.8 Seepage Management and Control

As presented in the *Conceptual Design*, seepage along the north line of STA-3/4 and the Supply Canal was to be collected in a seepage collection canal and returned to the treatment system through two seepage pumping stations, one located at either end of the seepage collection canal. That basic concept is unchanged in this preliminary design.

The *Conceptual Design* had contemplated the relocation of existing pumping stations G-200B and G-201 for use as the new seepage stations. In this preliminary design, seepage return pumping facilities will be housed in Pumping Stations G-370 and G-372. The existing pumping equipment at G-200B and G-201 has proved itself unreliable and requiring a high degree of maintenance. Given that new information, the seepage return pumps will consist of new vertically installed axial flow pumps driven by electric motors. Pumping station G-200B will be removed. Pumping station G-201 will remain in place

for future flexibility, but will be taken out of service during the initial or Phase 1 operation of STA-3/4.

Also as presented in the *Conceptual Design*, seepage along the east perimeter of the STA was to be gathered in a seepage collection canal and returned to the North New River through an existing culvert beneath U.S. Highway 27. Once returned to the North New River, the accumulated seepage would be in the headwater pool for Pumping Station G-370, and returned to the treatment area through that pumping station. That basic concept remains unchanged in this preliminary design.

Potential enhancements in seepage management and control included in this preliminary design include the provision of means to directly discharge accumulated seepage to receiving waters. These features, intended to enhance treatment performance and capability, include:

- Provision of operational means and physical facilities to direct accumulated seepage at G-372 to either the Supply Canal for return to the treatment area, or to the Miami Canal downstream of new Structure G-373.
- Provision of operational means and physical facilities to direct accumulated seepage at G-370 to either the Inflow Canal for return to the treatment area, or to the east seepage collection canal.
- The addition of a gate and controls to the existing culvert beneath U.S. Highway 27 (Control Structure G-384B) and the inclusion of an additional gated culvert (G-384A) at the south end of the east seepage canal. Those structures can be operated in tandem to either return accumulated seepage along the east perimeter (as well as seepage diverted at G-370) to the North New River and through G-370 to the treatment area, or directly to the Discharge Canal at its confluence with the east seepage collection canal.

Based on the results of analyses presented herein, it is not clear that the additional flexibility in seepage management afforded by the above modifications to the *Conceptual*

Design generate sufficient treatment performance benefits to warrant their cost. This topic is further explored in a subsequent section of this Executive Summary.

1.13.9 Projected Treatment Performance

The Conceptual Design was developed to result in a long-term flow-weighted mean TP concentration in outflows from STA-3/4 of 50 ppb, based on the original 1979-1988 base period, and excluding the influence of passing BMP makeup water (and its associated TP load) through the STA. Upon inclusion of the BMP makeup water, the projected performance of the Everglades Construction Project was shown in the Conceptual Design to degrade from that target outflow concentration of 50 ppb to 54 ppb.

Treatment performance projections presented in this *Plan Formulation* document suggest the potential for a wide range of long-term flow-weighted mean TP concentrations in outflows from STA-3/4. The anticipated minimum performance of STA-3/4 summarized in this section is developed consistent with the original design methodology and input parameters of the *Conceptual Design*, other than as follows:

- Average annual rainfall over the period 1965-1995 is taken as 50.8"; the *Conceptual Design* had assigned a value of 48.5" to the period 1979-1988. In this analysis, the average annual rainfall over 1979-1988 is taken as 46.1".
- Average annual evapotranspiration over the period 1965-1995 is taken as 57.1"; the *Conceptual Design* had assigned a value of 45.3" to the period 1979-1988. In this analysis, the average annual evapotranspiration over 1979-1988 is taken as 58.7".
- In the *Conceptual Design*, atmospheric deposition of TP was assigned as equivalent to a concentration of 50 ppb in rainfall. In this analysis, that value has been reduced to 30 ppb.
- The analyses conducted for the *Conceptual Design* did not consider the influence of seepage or varying seepage management strategies on treatment performance, due to a lack of specific information or estimates on seepage volumes. The influence of seepage has been included in the current estimates.

- Inflow volumes and TP concentrations have been updated as discussed earlier in this section.

Given only the above changes, and upon the assumption that all recoverable seepage is returned to the treatment area, estimated long-term flow-weighted mean TP concentrations in outflows from STA-3/4 are estimated at 44 ppb over the period 1965-1995, and 41 ppb over the period 1979-1988, demonstrating a high degree of confidence in achieving the interim goals established by the Legislature.

When other treatment analysis parameters (settling rate, background concentration, level of BMP performance) are adjusted to reflect additional information developed subsequent to completion of the *Conceptual Design*, treatment performance projections are further improved. The best estimate presently available is that the long-term flow-weighted mean TP concentration in outflows from STA-3/4 should range from 28-35 ppb, dependent upon BMP performance, but could range as low as 20-23 ppb.

1.14 FURTHER REFINEMENTS DURING DETAILED DESIGN

It is the District's intent that the preliminary design of STA-3/4 and the East WCA-3A Hydropattern Restoration presented in this *Plan Formulation* and its companion documents be subjected to the following additional reviews as the detailed design proceeds:

- An independent peer review by others under contract to the South Florida Water Management District.
- Review and comment by the public and other interested agencies.
- Continuing review by District staff and the Burns & McDonnell design team.

The objectives of those continuing reviews are to identify and implement additional opportunities to:

- Reduce the construction or operations and maintenance cost of the project without sacrificing treatment performance.
- Enhance (reduce) implementation schedules without sacrificing treatment performance or unreasonably increasing costs.
- Improve anticipated treatment performance without unreasonably increasing costs.

All such further refinements will be documented in detailed design reports to be prepared concurrent with completion of the detailed design and construction plans and specifications.

Certain refinements to the preliminary design presented herein and apparently consistent with the above criteria for implementing refinements have already been identified.

In the absence of any compelling counter-argument during the review of this preliminary design, the following refinements to the design should be implemented during the detailed design phase.

1.14.1 Elimination of Structure G-373

Structure G-373 is a diversion structure in the Miami Canal immediately downstream of the point of withdrawal from the Miami Canal for Pumping Station G-372. As presently contemplated, this structure would be normally closed, and would be opened only when necessary to:

- Bypass Lower East Coast water supply deliveries down the Miami Canal around STA-3/4.
- In the event of a major hydrologic event requiring a bypass of STA-3/4 to avoid endangerment of its physical works.

With respect to water supply deliveries to the Lower East Coast, it is noted that the federal *Comprehensive Everglades Restoration Plan* recommends removal of the Miami

Canal as a route for such deliveries, coupled with other substantive modifications and changes to the Miami Canal system. As a result, the use of G-373 for that purpose must be considered a short-term use.

The results of the operational simulation presented in detail in Section 7 of this Plan Formulation indicate no need for bypass of STA-3/4 given a repetition of the regional hydrologic conditions over the 31-year period 1965-1995. That period encompasses the largest events of record in the Central and Southern Florida Project for Flood Control and Other Purposes. In addition, the detailed design criteria for the physical works of STA-3/4 include provisions for major storm events to occur on top of the maximum stages projected in the operational simulation. As a result, it is not clear that the provision of emergency bypass capability at G-373 is warranted. Further, it is noted that a decision to delete G-373 is a reversible decision; the structure could be added at any point in time following completion of STA-3/4.

It is recommended that Structure G-373 be deleted from the design, and that the structure be replaced with a simple earthen plug. Given that this recommendation directly impacts the potential operation of the C&SF project, the concurrence in this recommendation of the Jacksonville District, U.S. Army Corps of Engineers is being sought.

1.14.2 Delete Capacity for the Direct Discharge of Recoverable Seepage

As noted in Section 10 of this *Plan Formulation*, little or no long-term value can be attached to the capability for direct discharge of recoverable seepage to the Everglades Protection Area.

It is recommended that:

- **Structure G-384A be deleted from the design.**

- **The addition of a gate and controls to G-384B (existing culvert beneath U.S. Highway 27) be deferred.**
- **The capacity for the diversion of recovered seepage at G-370 to the east seepage collection canal be eliminated from the design.**
- **The capacity for the diversion of recovered seepage at G-372 to the "treated water" segment of the Miami Canal be eliminated from the design**. Operational flexibility with respect to both STA-3/4 and the Holey Land Wildlife Management Area can be realized at nominal cost by including the potential for diversion of the seepage to the Holey Land. **The design of G-372 should include facilities to permit the diversion of recovered seepage directly to the Holey Land.**

1.14.3 Delete East Perimeter Levee Seepage Collection Canal

As indicated on Plate 12, there exists the potential for modification of the East Perimeter Levee and elimination of its adjacent seepage collection canal. That modification will require the concurrence of the Florida Department of Transportation, as there will be a need for shared use of certain facilities and the need for construction on FDOT right-of-way.

In addition to the obvious cost advantage of this change, it would avoid the need for temporary closure of U.S. Highway 27 as would be required during blasting operations necessary for excavation of the seepage collection canal.

The District is pursuing this modification with the Florida Department of Transportation.